Are Sustainable Structures Compatible with Common Sense?

By Bill Addis, Ph.D., MCIOB

All new structures are sustainable, according to the construction industry press. However, the truth is that no structures are sustainable under any definition of the word.

All new buildings use considerable quantities of non-renewable resources – minerals, fossil fuels and their products, potable water and (often) green-field sites. They also lead to considerable adverse impacts – pollution of air, groundwater and water courses, disturbance to wildlife and loss of habitats, and filling of landfill sites. A so-called "sustainable" structure is perhaps more sustainable than a "normal" one – it may use fewer resources and have a lower environmental impact – but not by very much.

Without getting deep into the business of quantifying sustainability, and ignoring the energy used to run buildings, the difference between the most sustainable structure and the worst similar building is much less than 1%. In other words, even if every new building achieves maximum points for structure-related issues using LEED, we are not doing much to save the planet. The same is true of all other large projects, including bridges, dams, tunnels, etc.

How did we get into the position of believing that we are now building super-sustainable structures? Mainly through the mania for measuring everything in order to be able to manage its delivery. It reminds me of the graphs on the financial pages of newspapers – you see share prices going up and down like spectacular mountain ranges. Then you look at the scale on the y-axis and see that its full range goes from 978 to 979.

This is not to suggest that we should stop considering the environment. Structural engineers have already been doing this, in the name of resource efficiency, for many centuries. The dome of St. Paul's cathedral in London, built in the 1680s, spans about 131 feet (40 meters) and weighs about 10,000 tons. The roof over the Breslau Jahrhunderthalle (1913) spans 226 feet (69 meters) and weighs about 1,000 tons. A large geodesic dome covering the same sort of span might weigh about 100 tons, and the roof over the Millennium Dome in London weighs less than the uplift due to wind.

Nowadays the weight of most average buildings or bridges is near the minimum due simply to financial pressures, not a sophisticated environmental assessment process. Indeed, even the embodied energy of structures is near the minimum, since the cost of materials generally reflects the amount of energy needed to extract them, make components and assemble them on site.

Should we just rely on market forces to achieve lower environmental impact? Definitely not; that is bound to lead to under-designed new structures, very short-life buildings and huge maintenance bills. Instead, we must fall back on common sense and engineering judgment. What are we actually trying to achieve, and for whose benefit? We must design structures with the big picture in mind – or rather, continue to do so, and keep getting better at it. We need to consider the whole life of the building, how it performs during that life, and how easy it is to maintain or adapt and update or, finally, demolish and recycle.

How long do structures last? A typical answer might be 60 years for buildings or 120 years for bridges, but plenty of good buildings are demolished before they are 20 years old. We do not know how long the Golden Gate Bridge will last, but the Brooklyn Bridge and Forth Bridge are still going strong after more than 120 years. You can come to nearly any answer you like in life-cycle assessment if you play around with the so-called "design life."

Many assessment tools now reward "innovative design." However, if a structural engineer comes up with a way to reduce the mass of a structure or the life-cycle impact by 20%, what happens when all engineers adopt this technique? It is no longer innovative and they get no reward, so there is no (environmental) incentive to use it.

I am amazed at the ingenuity, common sense and great skills of engineers who design earthquake-resistant structures. Their solutions include sacrificial plastic connections that prevent damage to other parts and can be replaced after an earthquake, self-centering bearings and structures that can rock on their foundations, and with flexible connections to utility services and infrastructure. Best of all, many existing buildings can be upgraded to meet modern seismic design codes; for example, installing buckling restrained braces to introduce predictable plastic behaviour and reduce the demands on the existing column splices and brace connections.

In this manner, the life of existing buildings can be extended and the worst option for the environment – condemnation, demolition and replacement – can be avoided. There is also a growing recognition of the need to pay more attention to non-structural elements, damage to which can often render a building useless even if the structure itself survives well. They can be designed to accommodate drift and permanent deformation of the main structure, and also to withstand accelerations encountered in earthquakes.

Yet none of this excellent engineering is adequately rewarded by environmental assessment methods such as LEED.

Where does that leave us? I am optimistic that, left to themselves, by adopting a common-sense approach to building performance specifications, most structural engineers will come up with new ideas that benefit their clients as well as the environment. We should continue using our skill and judgment, considering the whole life of the structure and how to reduce long-term maintenance costs; this is bound to be reflected in the residual value of structures. So the answer to the question in the title is "yes," but only if the assessment industry worries less about bean-counting and pays closer attention to what good engineering really is.▪

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